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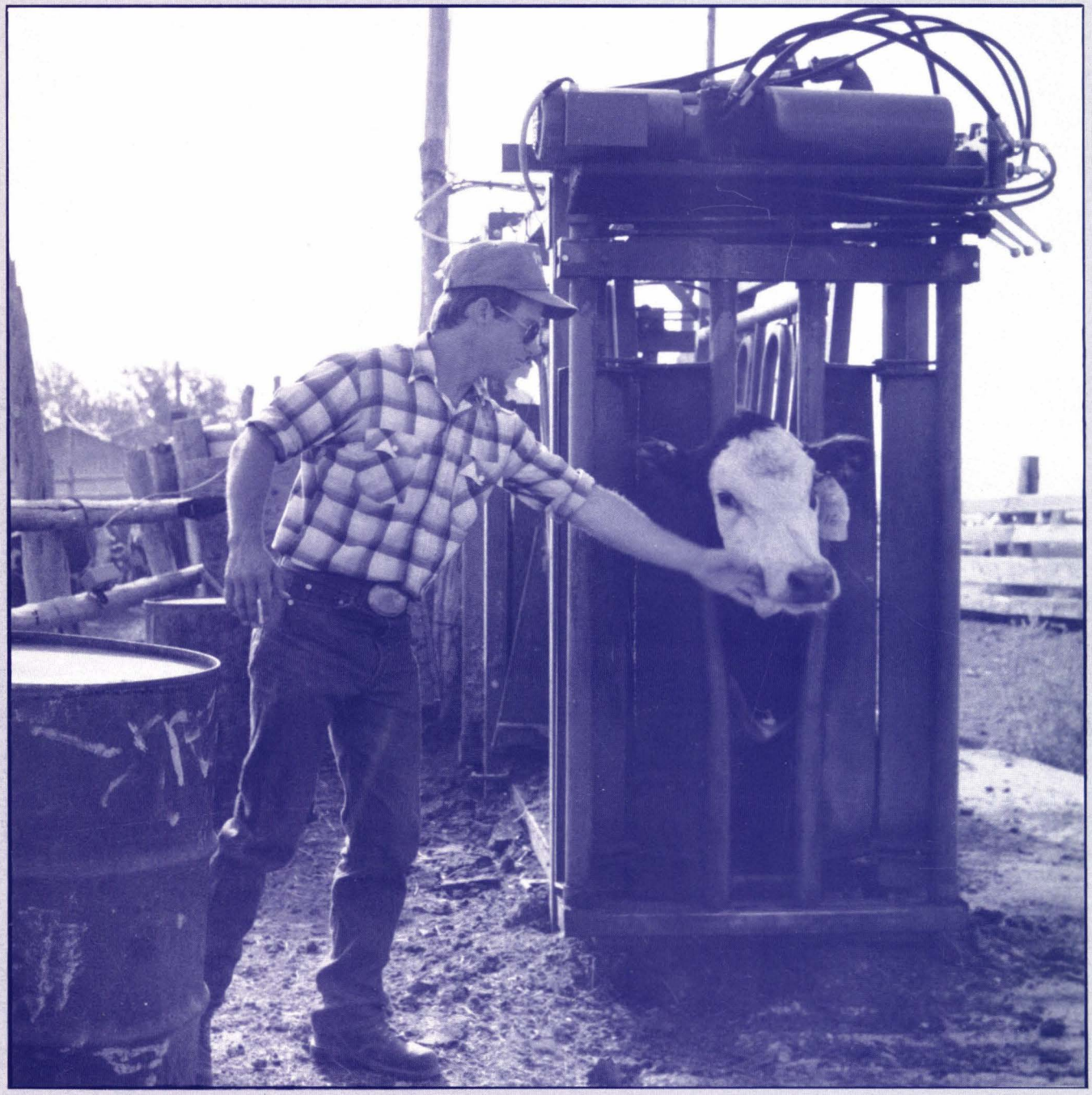
Forest Service

Forestry Research West

October 1993



A report for land managers on recent developments in forestry research at the four western Experiment Stations of the Forest Service, U.S. Department of Agriculture.

Forestry Research West

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Private rancher Dave Baker attaches a special eartag to a heifer. The tags are part of an experiment being conducted by Pacific Northwest Station scientists. They are working on a system to control livestock movements by training them to respond to remotely controlled auditory and electrical stimulation. Ultimately, they intend to develop an inexpensive electronic fencing system that will prevent cattle from entering designated areas such as riparian zones. Details begin on page 1.

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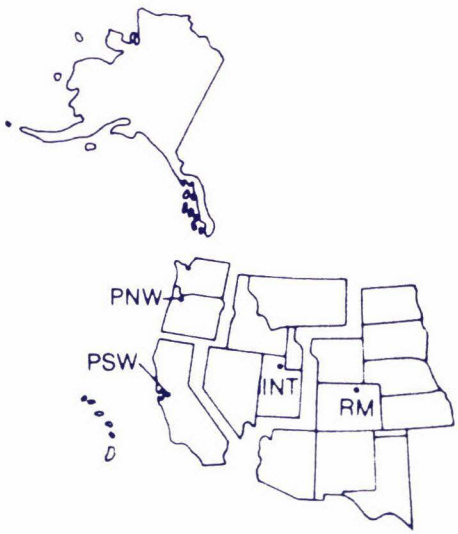

Electronic eartags: reinventing the fence

by Les Ozawa
Pacific Northwest Station

Riparian ecosystems sustain life and livelihoods far beyond the streambed itself. Research indicates intensive grazing of a riparian area can adversely affect a stream's water quality. Overgrazing can also quickly reduce vegetation diversity and streambank structure. It is not surprising then, that cattle grazing in riparian areas on public lands is under intense public scrutiny.

Limiting livestock access to riparian areas is an obvious solution. The question is how. Costly solutions include closing off grazing allotments or using herding more extensively. Fencing is a more common solution. For centuries, man has used rocks, wood, and wire to construct physical barriers to prevent access into and out of a prescribed area.

Texas yearling steer wears insulated electronic eartag number 8.

But fences have drawbacks. Especially in mountainous, rocky terrain, they are expensive to build, up to $5,000 a mile, according to one estimate. Fences also are not selective. "They keep cattle out, but they also block access to the recreating public," said Tom Quigley, a range scientist with the Pacific Northwest Research Station's Blue Mountains Natural Resources Institute in La Grande, Oregon. "Wildlife can get caught up in fences," he added. Fences require gates and are prone to damage from flooding. Fences are also more or less permanent. Land managers need to be very careful about where they place them, because once they are in, they likely will be in place for a long time.

Advantage of electronic fences

Can cattle ever live compatibly with salmon and other denizens of our forests and rangelands? Taking a cue from dog trainers using electronic collars, Quigley and Art Tiedemann, a fellow Forest Service scientist in La Grande, are developing a way to control livestock movements by training them to respond to remotely controlled auditory and electrical stimulation. Ultimately, they intend to develop an inexpensive "electronic" fencing system that will prevent cattle from entering designated areas such as riparian zones.

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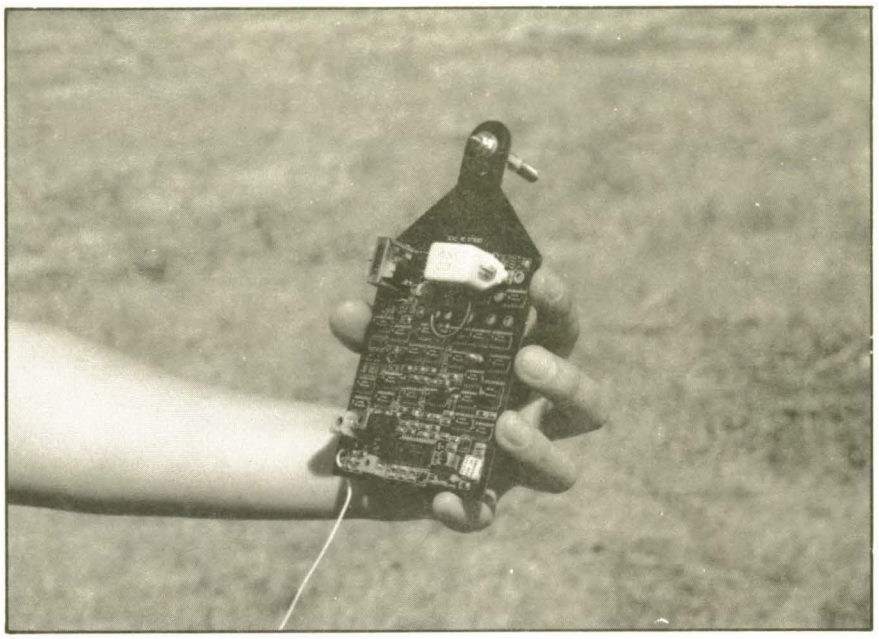
Electronic fencing has two key advantages. First, it allows selective access. Through coded signals, a certain herd could be kept away from a prescribed area, while other animals (including humans) are allowed free access.

Second, the "fence" is "portable." By turning off the transmitters and moving them, land managers can "obliterate" and set up fences at will.

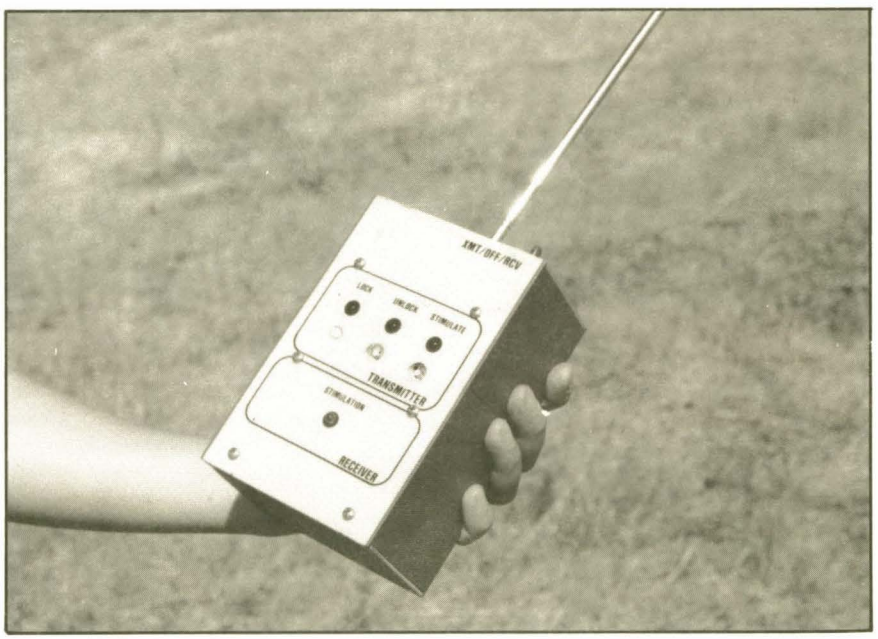
When tests on four steers with modified dog collars in 1990 proved promising, Quigley and Tiedemann took their idea further: they began work to improve the technology and to develop techniques for use on cattle herds in controlled field conditions.

"We switched to eartags, because collars are expensive to build and difficult to handle on cattle," said Quigley. "Eartagging is done routinely by livestock people, and if we could get the unit contained in an eartag, animal handling would be reduced tremendously," added Tiedemann.

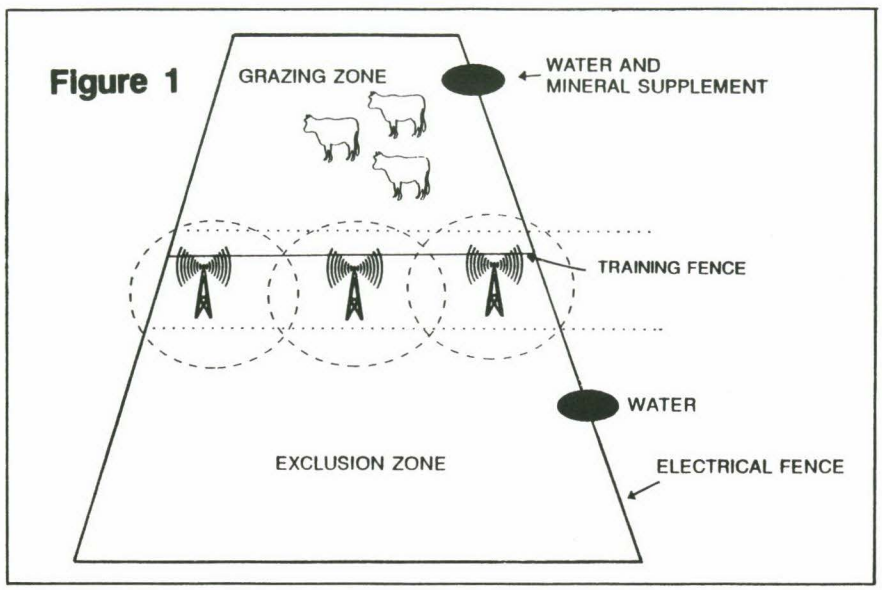
With a $99,000 EPA grant, Quigley and Tiedemann contracted with Schell Electronics of Chanute, Kansas, to design and manufacture transmitters and receivers for the system.



Prototype electronic eartag can be programmed for various warning patterns.



Hand-held unit can activate, deactivate and test electronic eartags.



Training pasture configuration for Texas tests.

The prototype eartag is 3 inches wide and 6 inches long, about twice the length of a conventional identification eartag. When insulated and fully equipped, the eartag weighs 4 ounces. Power is supplied by two AAA batteries. The portable transmitter, also built by Schell, is designed to transmit a coded signal continuously. It can transmit at five different signal strengths, so its range can be adjusted between 100 and 500 feet.

The eartag was originally designed so that an animal would first receive a warning in the form of a high-pitched sound, if it approached a transmission (exclusion) area. If it moved away, it would receive no further stimuli. If, however, the animal remained in the exclusion area, after four seconds it would receive a mild electrical stimulus. The animal could be electrically stimulated up to two more times, with 4-second pauses between each stimulus, to allow it time to move outside the exclusion area. Thereafter, the receiver automatically "locked up" (shut itself off), to protect the animal. To develop range control techniques, Quigley and Tiedemann took their electronic devices to Texas and Nevada for two field trials last summer.

The Texas tests

In mid-June 1992, in cooperation with the Texas Agricultural Extension Service, 90 yearling steers were tested for 9 days at the Scott Petty Ranch in Yancey, Texas. The pastures were shaped like wedges of a pie, each 1,600 feet long, 30 feet wide at the narrow end, and 800 feet wide at the outer edge (see fig. 1). Several transmitters were aligned to establish exclusion boundaries at various distances from the narrow end of the pasture.

The researchers learned several things from the Texas tests. "We learned it is essential that the animals are trained before they're released in areas with electronically defined exclusion zones," said Tiedemann. After testing various training regimens, Tiedemann and Quigley feel a temporary electric fence aligned to the transmission zone may be all that is needed. The researchers learned that it is important to identify and properly train lead animals in a herd. The other animals would sometimes follow the lead animals into the exclusion zones, even though they had to endure the full series of electric stimuli.

The Texas tests also led to changes in the eartag stimuli. The animals seemed to react to insects in the same way they reacted to the high-pitched (8,500 hz) tone. Also, the electric stimulus of 1 second caused some animals to wheel around completely instead of turning away from the exclusion zone. For the follow-up Nevada tests, the eartags were modified to emit a lower-pitched (850 hz) tone. The duration of the electric stimuli was shortened to 1/8 of a second.

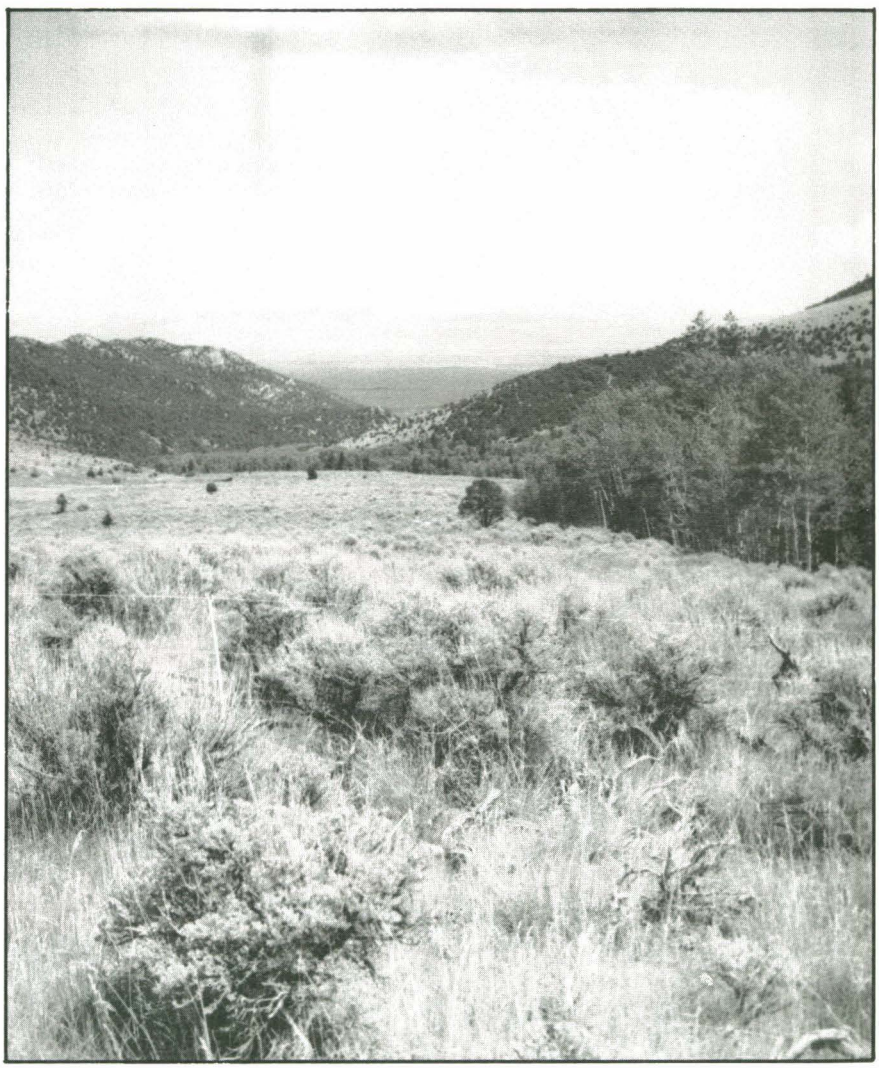
Another important modification was a change to the stimuli pattern. "We wanted the animal to associate the auditory stimulus with the electric stimulus," said Tiedemann. The researchers reprogrammed the eartag so that the animal would hear an audible tone before each electric stimulus It was hoped the animals would learn to react to the warning tone, move out of the exclusion zone, and avoid the ensuing electrical stimulus.

A major innovation to the transmission-receiving system was the addition of a remote unlocking transmitter set up in an "unlock zone"—an attractive area like a water, salt, or mineral location outside the exclusion zone. Animals with locked up receivers that moved into an unlock transmitter zone would automatically have their eartag receivers reactivated for future encounters with the electronic fence.

Transmission difficulties occurred during the Texas tests. Because higher humidity at night seemed to increase signal distances, transmitter strengths were lowered at the end of the day to maintain the exclusion zone in the pasture. Also, when animals grazed close together, some animals blocked signals from reaching receivers on nearby animals. This resulted in some animals getting confused when they were stimulated inconsistently because of signal interference.

The Nevada tests

The Nevada tests took place in August at the Great Basin National Park at Baker, Nevada, with 90 yearling heifers provided by Dean Baker Ranches. The study site was the Strawberry Creek basin, a relatively flat, open valley about 1.5 miles long and a quarter to half mile wide. Its riparian area consists of conifer and aspen interspersed with small openings. The valley itself is sagebrush grassland.



Strawberry Creek basin, Great Basin National Park.

Three control and three treatment pastures were set up, each consisting of a section of the stream, a riparian area and a grazing area. The pastures were 500 to 800 feet long and 250 to 400 feet wide (see fig. 2).

The Nevada tests confirmed that electronically eartagged cattle quickly learn to avoid an exclusion area when an electric fence is used as a visual cue during training. During a 1-day training period, the researchers observed 23 correct responses and 2 incorrect responses among treatment animals approaching the electronic fence.

After being trained, the animals were moved into the test pastures around Strawberry Creek. Over the next 3 days, researchers observed the electronically eartagged animals make 32 correct responses an 4 incorrect responses when they approached the exclusion areas. Some of the incorrect responses were attributed to defective eartags that were apparently damaged when the cattle were trucked up a primitive road to the Strawberry Creek pastures.

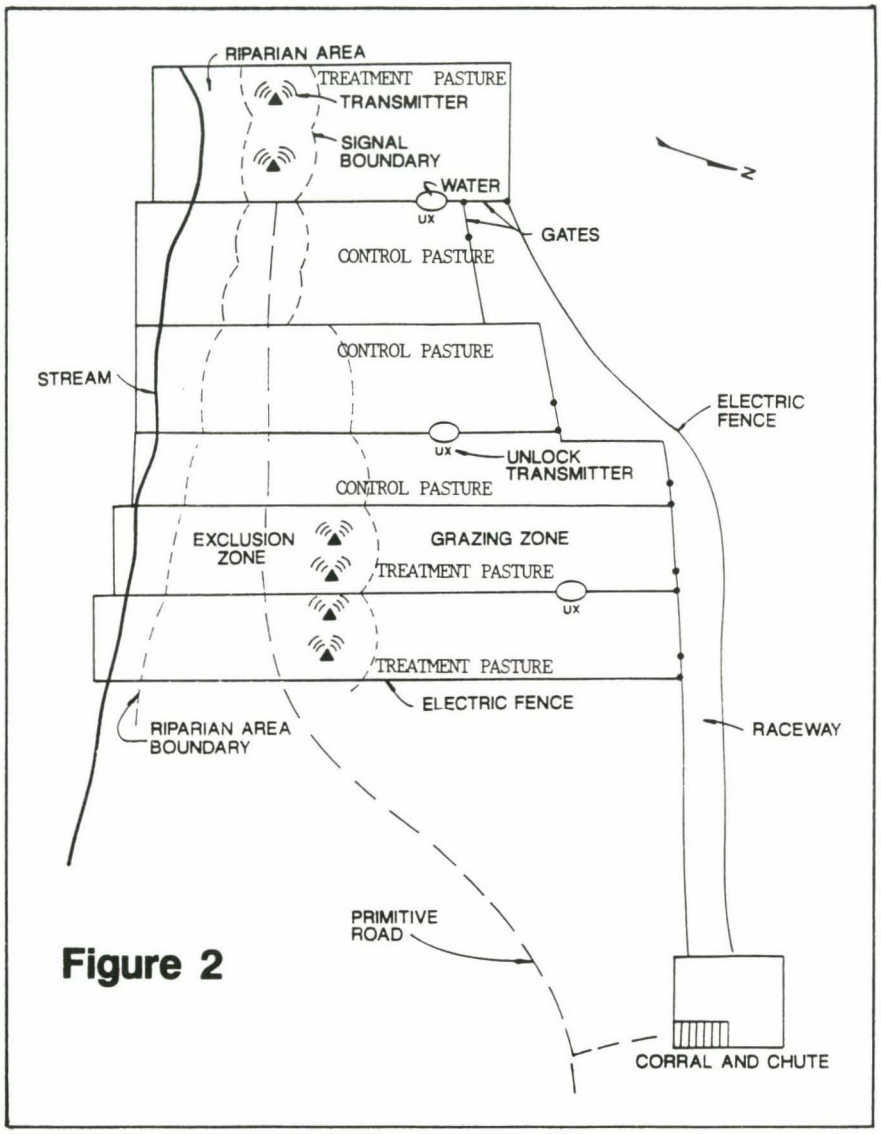


Figure 2

Treatment and control pasture configurations for Nevada tests.

But the electronic fence worked. During a 1-day test, all the animals in a treatment pasture stayed outside the electronically defined exclusion zone. In contrast, in the control pasture, cattle were observed 44 percent of the time in their "exclusion zone."

"The Nevada tests reinforced our optimism from the Texas tests that the technology is there and can work," said Tiedemann. "Lowering the pitch of the auditory signal and shortening the duration of the electrical stimulus were especially effective."

"The use of 'unlock zones' is one of the changes we feel very positive about," said Quigley. "It allows the animals to train themselves. Our training period won't need to be as long in the future."

What's next on the research agenda? "We need to make the eartag unit smaller, lighter, and more durable," said Quigley. "The technology is available. It's a matter of investing in engineering design so that the pieces fit together correctly." The goal is to ultimately reduce the weight of the eartag to about an ounce, and to employ a battery that will last through one grazing season (about 6 months). The eartag must also be able to survive being chewed on and getting banged up on water troughs and fence posts.

"We also didn't have time during these short trials to see if the animals could be sufficiently trained to respond to audio warnings alone, so that they would learn to avoid receiving electrical stimulation," said Tiedemann.

During summer 1993, with a SACHEM Fund grant, Quigley and Tiedemann worked with Oregon State University scientists to assess the influence of eartag stimuli on animal health, physiology, and behavior. They also worked cooperatively with the Burns and Vale Districts of the Bureau of Land Management, to determine the responses of cow-calf pairs to the eartag technology.

Many private and public partners have cooperated in various phases of the electronic fence research. They include two ranches, four state agencies, five Federal agencies, a state university, a private foundation and an electronics firm.

How long will it take for electronic eartags to be on the market?

"Optimistically, if the stars line up and we continue as planned, in 2 years," said Quigley.

For more information about the electronic eartags, contact Art Tiedemann or Tom Quigley at the Forestry and Range Sciences Laboratory, 1401 Gekeler Lane, La Grande, Oregon 97850.

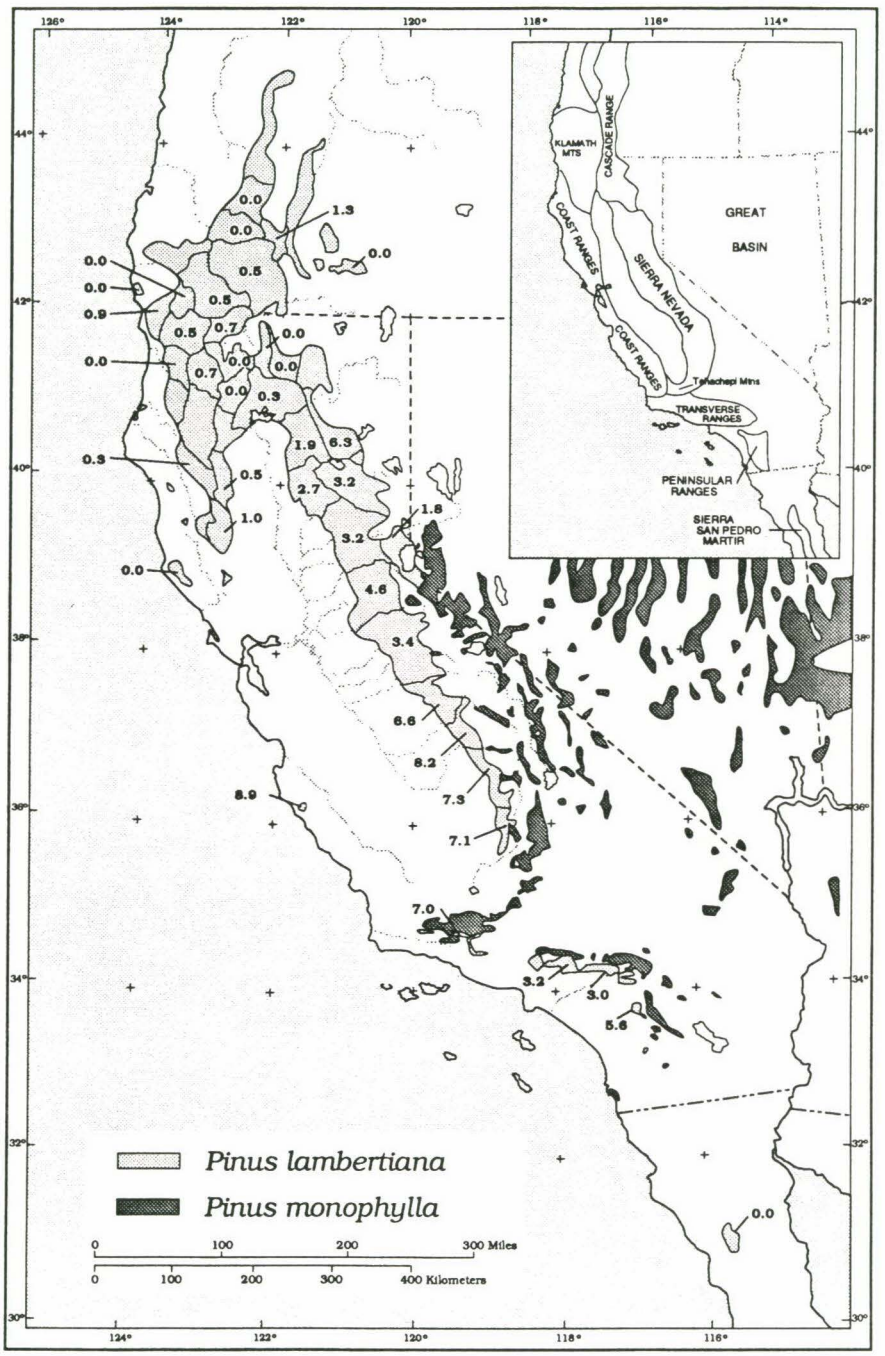
Sugar pine and blister rust: a not-so-simple genetic solution

by J. Louise Mastrantonio, for Pacific Southwest Station

Back in 1970, when a young forest geneticist identified a single dominant gene for resistance to blister rust in sugar pine, it seemed like an easy answer to a problem that had plagued western forestry for decades.

Today, nearly twenty-five years later, that discovery is still considered a major breakthrough against the deadly white pine blister rust, a rust disease of white pines that is especially virulent against sugar pine. Now, however, optimism is tempered with a stiff dose of reality and the knowledge that the single dominant gene, labelled "MGR" for major gene resistance, is only a stop-gap measure and that saving the sugar pine as a major commercial species in California and Oregon forests will be an on-going effort.

At the U.S. Forest Service's Pacific Southwest Research Station in Albany, California, Forest Geneticist Bohun Kinloch was the first to identify the MGR gene. He explains why saving the sugar pine has not been an easy task.



Distribution and frequency of the "R" gene for blister rust resistance in the natural range of sugar pine.

The Disease

First of all, the disease. "Blister rust is a formidable problem," Kinloch says. It is caused by a fungus, *(Cronartium ribicola* Fisch). This fungus is similar to many other plant "rusts" in that it has a complex life cycle that includes five different spore stages and two alternate hosts — white pine trees and *Ribes*, wild gooseberries and currants. To live and reproduce, the fungus must spend time on both hosts; spores produced on pines will only infect *Ribes,* and only spores produced on *Ribes* will infect pines.

The disease is spread by spores that burst from sac-like pustules or "blisters." Spores are carried by the wind as far as 300 miles. From the initial infection site around the stomata (microscopic pores on the underside of the needle), the rust spreads, first to the branch, then into the stem. Eventually the disease girdles the stem, limbs die, and the entire tree is destroyed.

Blister rust is not native to North America and so poses special control problems. The fungus came here by way of Canada and Europe but probably originated in Asia where several species of white pine are native. It was discovered in Victoria, B.C., in 1920 and traced to a shipment of white pine seedlings that came from Europe in 1910. From British Columbia, it spread east into the Inland Empire and south into Washington and Oregon, reaching California about 1930. None of the North American white pines were prepared to cope with this intruder and the results have been devastating.

Control efforts

In the early stages of the epidemic, foresters tried to control the disease by getting rid of the alternate host — the *Ribes* bushes. In the 1930's and 1940's, more than a hundred million dollars was spent to eradicate *Ribes*. Other intensive cultural methods were tried, including spacing control, pruning, and removal of infected trees. None did more than slow the spread of the disease.

A gene for resistance

Kinloch came to the Pacific Southwest Station in 1968. His assignment was to work on the general problem of pest resistance in conifers. By then, foresters had noticed trees that seemed to be less susceptible to the rust and had begun to test them for resistance. In 1961, a "disease garden" was established in the Klamath National Forest near Happy Camp in northern California. Potentially resistant trees were planted there and exposed to *Ribes* infected with blister rust.

Kinloch was drawn to this work. It was the biggest thing going in pest resistance in the region at that time and he became engrossed in it.

From his observations at Happy Camp and from work at the forest nursery and Institute of Forest Genetics at Placerville, Kinloch learned that a single dominant gene, MGR, was responsible. This was determined through visual observation — by the number of seedlings that survived in the test garden. Because the gene is dominant, "at least half the offspring of any resistant parent are also resistant," Kinloch says. Open-pollinated seedlings (those with a known seed parent and an unknown pollen parent) segregated neatly into a simple Mendelian ratio for dominant genes (50 percent resistant: 50 percent susceptible).

All diploid organisms (higher plants and animals, including humans) have a double set of homologous chromosomes, one set inherited from each parent.

Genes are arrayed in a linear fashion along the chromosome "strip". Each individual has two genes that control a particular characteristic. Often, they are identical. In sugar pine, there are two forms of a gene that controls resistance or susceptibility to blister rust. One ("R") gives rise to resistance, the other ("r") causes a tree to be susceptible. If an organism is RR or Rr, it will be resistant (R being dominant); if it is rr, it will be susceptible.

Trees with MGR are readily identified. Not only do they exhibit long-term resistance (survival) to blister rust, they also have an initial hypersensitivity to infection. Instead of developing the bright yellow spots typical of blister rust infections, needles of resistant trees develop small necrotic flecks. The tree reacts so rapidly to the fungus that the surrounding tissue dies and with it, the fungus.

Discovery of MGR was a stroke of biological good fortune. But for tree breeders and forest managers, the job was just beginning. The gene is relatively rare in the sugar pine population and not evenly distributed. At the northern range of sugar pine, trees with the gene are extremely rare; in the Sierra Nevada, at the highest rate of frequency, only sixteen in a hundred have it.

"V" is for virulent

Just as optimism was growing over the MGR gene, Kinloch and his co-workers found a very virulent strain of the blister rust at the Happy Camp test site. Dubbed "V" for virulent as opposed to "WT" for the common wild type, this new rust not only attacked and killed susceptible pines, it also killed trees with MGR. Most likely a mutation, it quickly replaced the wild strains of the rust at that site.

Other types of resistance

Discovery of the mutant "V" rust could have ended the genetics work. Instead, it sent scientists looking for other mechanisms of resistance. Two other types of resistance have also been identified: (1) slow rusting resistance (SRR) and ontogenetic resistance (OGR). SRR exhibits a low rate of infection along with a high rate of infections that abort and heal over. OGR develops over time and does not show up until a tree is older. Both types of resistance have potential for use in tree breeding.

A question of evolution

An interesting question in the blister rust work is the origin of the MGR gene. Major diseases and mechanisms for survival usually co-evolve with the host plant so why should sugar pine carry a gene for resistance to a disease not native to North America?

One possibility is that MGR is an isolated "relict" in the gene pool, a gene left over from some long-ago time when it served a similar purpose. Several things point toward that. First, R is expressed as hypersensitivity, "a common reaction to pathogens in plants," according to Kinloch. The original function of the R gene may have been resistance to a similar disease. One possibility is the rust disease of pinyon pine (*C. occidentale).* Sugar and pinyon pine are seldom found together now, but fossil evidence from rat middens indicates that the two species once grew in close association. This would have provided an opportunity for sugar pine to develop resistance to blister rust.

A control strategy

The present strategy for managing sugar pine involves the coordinated effort of research and various land management organizations and includes several parallel efforts:

- Incorporate the MGR gene into sugar pines for planting in timber harvest areas. As a result of research and the efforts of the National Forest System, trees with MGR are increasingly being planted in California National Forests. This resistant stock will serve as a first line of defense against the disease.

Because forest trees are rather closely adapted to site, seed for planting in a given location must be taken from areas of similar elevation and latitude. In California National Forests, for example, there are six breeding zones for sugar pine. Over the last ten years, more than 9,000 trees have been evaluated by the National Forest System for resistance to blister rust and more than 500 have proved to be resistant.

Initially, seed for reforestation purposes is collected from cones of resistant trees in the forest. As the program gets underway, it comes from seed orchards that produce genetically improved seed grafts from resistant trees.

- Continue research on other types of genetic resistance and incorporate those genes into the planting stock. These will be needed when, and if, the "V" rust becomes more widespread.

- Map the genetic code (DNA) of sugar pine and isolate the gene responsible for rust resistance. Eventually, this may enable scientists to reproduce (clone) the genes for reforestation purposes.

Already more than fifty years have been devoted to controlling the deadly blister rust in sugar pine. Because other efforts have failed, genetics is the last hope for this stately, beautiful, and highly valuable western conifer.

"We can't afford to become complacent," Kinloch says. "The problem is not solved."

A research-management partnership

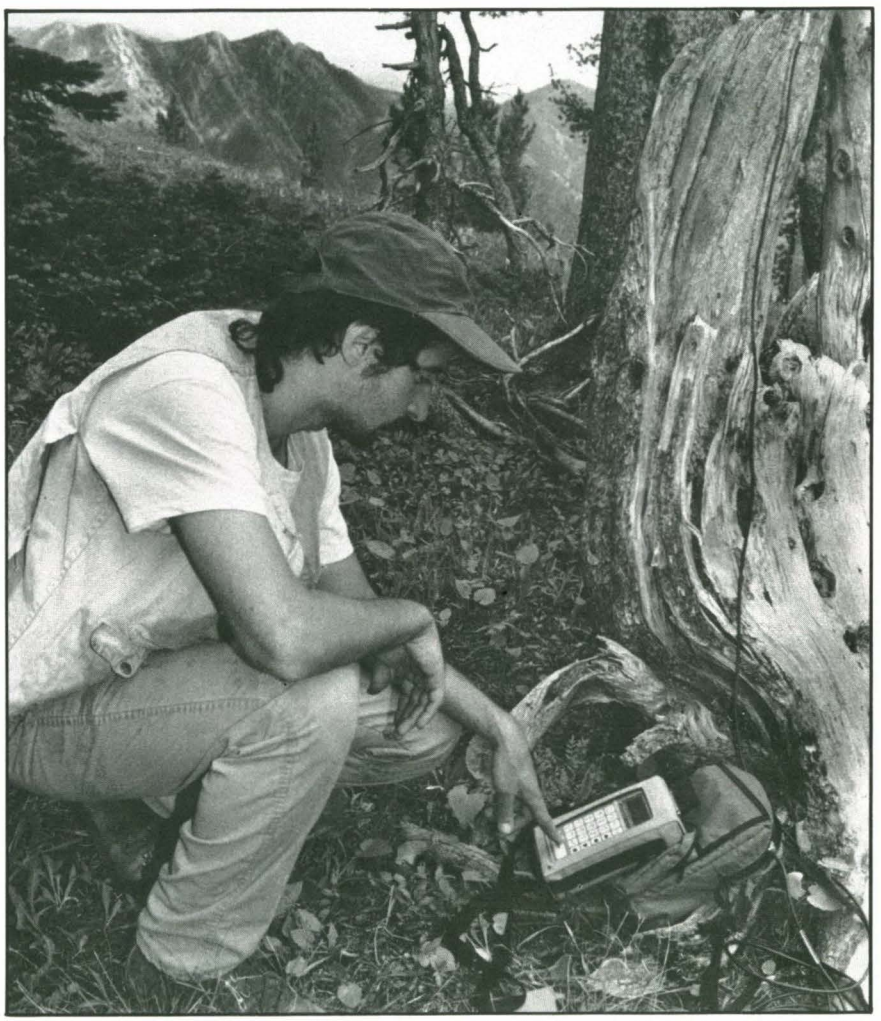
by David Tippets
Intermountain Station

For anyone skeptical that Forest Service "Ecosystem Management" is just old perspectives in new clothing, the working relationship between the Northern Region's ecology program and the Intermountain Station illustrates a new approach to linking science and management. The relationship shows a commitment to basing ecosystem management on good science and bringing science and management closer together.

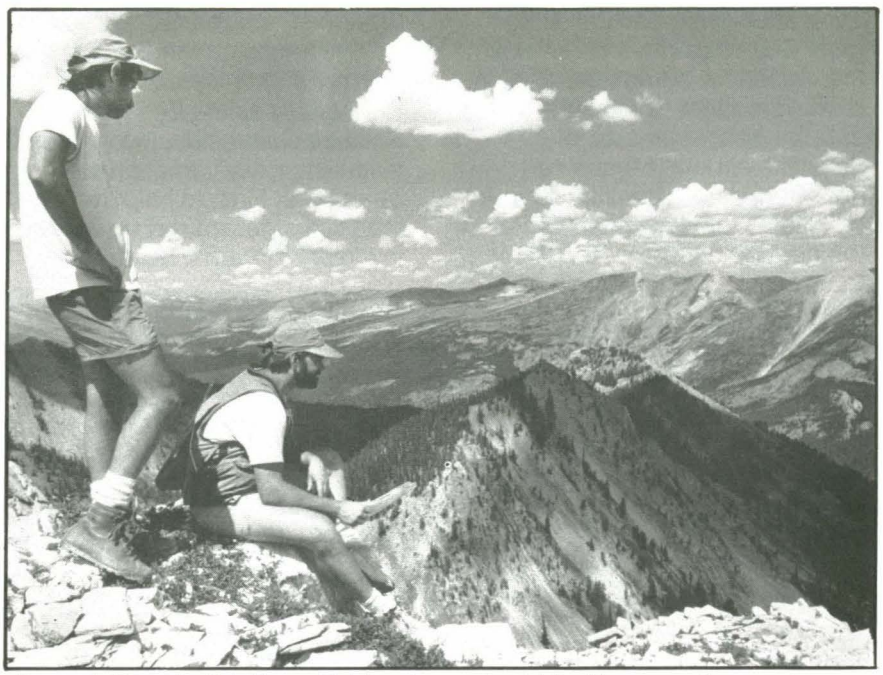
"The ecology program is one of the few places where management has caught up with research because of the new emphasis on ecosystem management," Intermountain Station Research Ecologist Bob Keane says.

Because the ecology program is bumping against the frontiers of science, Keane finds himself in a unique position working between research and management. He works for the Fire Effects unit at the Intermountain Fire Sciences Laboratory in Missoula, but is also involved in helping develop the Region's ecology program. The Region also provides support for his research and considers Keane part of its ecology staff. He provides the Region expertise in quantitative ecology and develops computer models for ecological processes, such as natural fire and forest succession.

Even after hiring several ecologists with doctorates to develop the ecology program, the Region discovered that, without additional support from scientists, the scientific expertise wasn't adequate to deal with all the complexities of an ecosystem. To gain the needed expertise, the Region organized a scientific advisory committee comprised of both agency and university scientists. Referred to as the Ecosystem Science Committee, the group of scientists initially accepted two objectives: First, to help the land managers design monitoring and inventory systems; Second, to



Intermountain Research Station Forester Jim Menakis uses a Geographical Positioning System to record a plot location using satellites orbiting overhead. Working with Research Ecologist Bob Keane, Menakis is evaluating the application of the technology for use in conjunction with Geographical Information Systems for ecosystem management.



Research Ecologist Bob Keane (right) and Forester Jim Menakis plan study plot locations from Shale Peak, high in the Flathead Alps portion of the Bob Marshall Wilderness complex. Spanning the Continental Divide and including an area of about 1.5 million acres, the complex provided Keane with an excellent research area for developing tools and methods for landscape ecology and ecosystem management.

help them develop strategies that conserve ecosystem processes, functions, and provide for ecosystem health and long-term sustainability.

The committee identified the need to collect new kinds of data to monitor ecosystem processes and sustainability. The kinds of integrated resource inventories being developed by the research-management partnership are driven by a new need for deeper ecological understanding and have little resemblance to the traditional range analysis and stand exams conducted to inventory natural resources.

The way the Northern Region has continually improved its inventory program, ECODATA, to incorporate more scientific expertise demonstrates the adaptive management style believed by many to be essential to successful ecosystem management. Keane has worked with regional ecologists Mark Jensen and Wendel Hann for years to test and refine ECODATA and ECOPAC, the analytical software for interpreting the inventory data. The methodology is evolving apace with new research information.

Inventory builds the foundation

The Region recognizes that ecosystem management must be built on a foundation of knowledge about the components of the ecosystem and an understanding of the range of natural variation. Understanding ecosystem processes and functions is also fundamental to building a solid foundation for ecosystem management. That means ecological inventories must be done before the foundation can be completed. Only after an ecological inventory is done can the landscape be characterized in ways that allow managers to make ecologically conscious decisions.

"We need to find simple ways to gather data that provide information about landscape patterns and ecological processes," Keane says. To meet the needs of ecosystem managers, Keane has developed new tools and methodologies, and is finding ways to link them on the landscape. That means inventory tools and methods must be linked to a Geographical Information System (GIS) so that the data can be interpreted over an entire ecoregion. GIS is the primary tool that will provide managers with an interpretation of ecological data and help them understand the potentially broad ecosystem impacts resulting from management alternatives.

Research Ecologist Bob Keane works with volunteer Brian Parks collecting fuel data that will be fed into an ecological process model that is essential to implementing ecosystem management in the Northern Region.

"We have to show people that landscape ecology is possible," Professor Penny Morgan from the University of Idaho Department of Forest Resources says. Morgan has worked with Keane to investigate how satellite imagery can be used to monitor ecological change over much of the Northern Rockies.

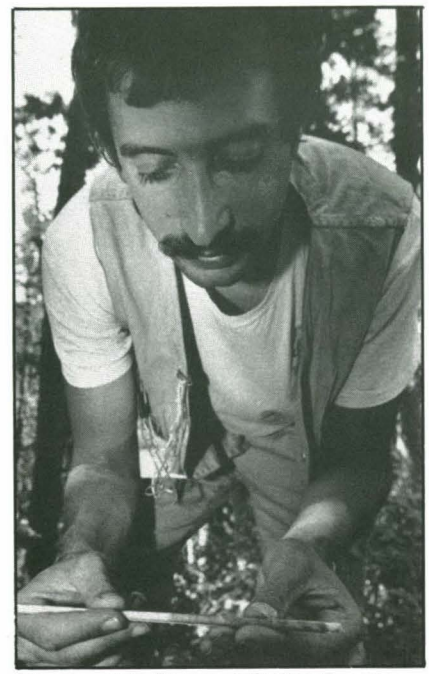
Keane selected the Bob Marshall Wilderness Complex as a study site. Over 1.5 million acres, the complex spans the continental divide, and includes parts of four National Forests and part of a biosphere reserve that runs north across Glacier National Park and into Canada. It is one of the few ecosystems in the continental United States that's still intact enough and large enough to support both grizzly bears and the gray wolf. The study area has everything needed to demonstrate the application of landscape ecology.

Ecosystem process

Keane is investigating how the ecological processes of fire, insects, and disease are influencing the succession and survival of whitebark pine. The pine is a particularly good subject for evaluating ecological monitoring tools and methods. Within his study area the pine grows on the edge of its range and is sensitive to ecological change. Whitebark depends on the natural ecological process of fire for regeneration, and also depends on a bird, the Clark's nutcracker, to plant its seed. The tree is also susceptible to white pine blister rust, a pathogen that is a major ecological disturbance.

Focusing research on the whitebark pine has added ecological significance because whitebark pine forests are important habitat for the grizzly bear. The pine's nuts provide an important late-season source of fat and protein to prepare the bear for hibernation.

The feasibility of computer modeling of ecological processes influencing the whitebark pine is also aided by other scientists studying different aspects of whitebark pine ecology. In 1991 the Intermountain Station nominated eight university and agency scientists for the Forest Service's Centennial Conservation Award for their research on whitebark pine ecosystems.



Intermountain Research Station Forester Jim Menakis collects tree growth data for use in an ecological process model being developed to support the implementation of ecosystem management.

Keane's computer model of forest succession in the whitebark pine ecosystem will show managers the responses to changes in ecosystem processes. For example, how will the current level of prescribed natural fire impact future whitebark pine ecosystems? What about in combination with blister rust and pine beetles?

To give managers a more complete picture of the ecosystem succession, models are used in combination with other models, such as FIRESUM. FIRESUM, an ecological process model for fire succession, was one of the first ecosystem management tools Keane developed with Steve Arno and Jim Brown, also with the Fire Effects unit. FIRESUM and many other similar computer models of ecosystem processes must be tied together with another computer program that will unite the models for a more complete ecosystem and landscape simulation. GIS will display the results in a way that managers can use to make decisions that are ecosystem based.

Ecosystem functions

Whitebark Pine ecosystems also provide an opportunity to learn methods for understanding and monitoring ecosystem functions. The hydrologic, energy, and nutrient cycles are all influenced by the ecosystem disturbance processes that drive forest succession. And the succession itself from pine to subalpine fir will change ecosystem functions.

The snowpack retention and protection characteristics of a whitebark pine forest are much different from those of the subalpine fir forest that follows it if natural ecosystem processes don't maintain the area in pine. The pine forests tend to trap the snow and delay the snowmelt better than the fir forests. Because fir forest have a different structure

and greater leaf area they intercept more snow, resulting in more evaporation of the precipitation.

Fir forests provide more shade, and less of the sun's energy reaches the forest floor. Less of the sun's energy is captured by plants in the understory, reducing the flow of energy to those herbivores that live on the forest floor. The way energy is captured and stored in the overstory also is different. In the case of whitebark pine the energy stored in the pine's nuts is an important energy source to fuel the grizzly bear through hibernation.

Nutrient cycles that influence site sustainability and production are also observable in studying the whitebark ecosystem. Subalpine fir trees retain their needles longer than the pines, keeping more nutrients in the crowns and slowing the process of decay and return of nutrients to the soil.

Recognizing the need for information about ecosystem processes and functions has influenced inventory design. With the help of the scientific committee, the Region is finding ways to measure and monitor things like leaf area and needle retention. There is more concern for measuring organic matter on the forest floor and learning the status of mycorrhizal fungi functioning in the nutrient cycle. The Region now has an ecosystem-process/function inventory rather than the traditional ecosystem-state inventory.

Committed to the belief that ecosystem management must be based on good science, Northern Region Ecologist Wendel Hann (right) supported the Intermountain Station's research in the Bob Marshall to the extent he even provided the logistical support for scientists to collect data from the most remote parts of the 1.5 million acre study area. Even though the researchers used some of the most advanced technology, they still depended on packstock, one of the oldest technologies applied to forest and range research.

Although ecosystem research has already produced new management recommendations, the work also gives added appreciation to the complexity of ecosystems and how much research still needs to be done. It helps us realize that ecosystem management is more of a journey than a destination, and is a commitment between science and management working together.

As for the whitebark pine ecosystem within the Bob Marshall Wilderness complex, Keane can demonstrate scientifically what many have hypothesized. With the current combination of ecosystem processes set in motion — mountain pine beetle, blister rust, and natural fire much less frequent than the historic level — whitebark pine will almost disappear. Using GIS and computer models he can show with respect to time and space on the landscape when and where it will disappear. But using the same tools, he can also demonstrate a brighter future for the ecosystem if fire as a natural ecosystem process is restored to its historic frequency.

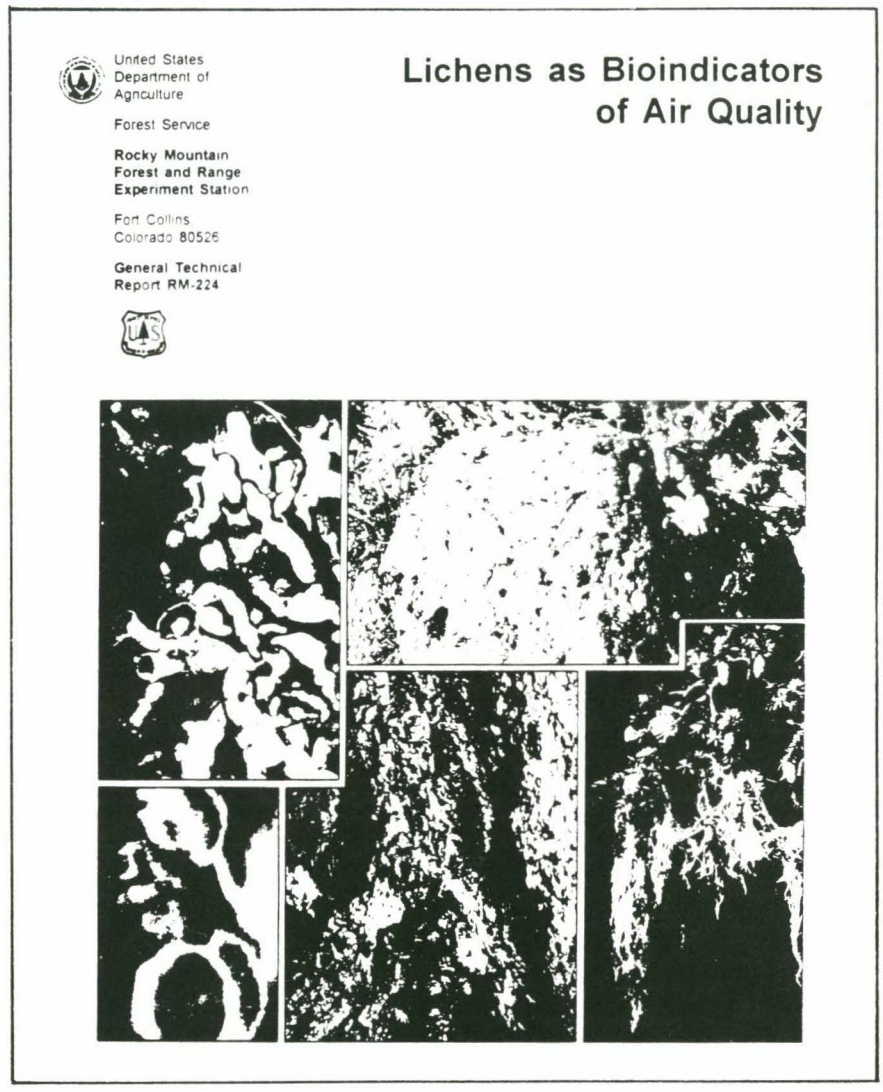
Keane's research has given managers an opportunity to make ecosystem management decisions for "the Bob" based on good science. And his research has developed the tools and methods that will allow managers to make management decisions in other parts of the National Forest System.

Lichens as biomonitors?

by Rick Fletcher
Rocky Mountain Station

Lichens are a group of non-vascular plants composed of fungal and algal species growing in a symbiotic relationship. The fungi supply structural support to the organism, and the algae supply nutrition through photosynthesis. Lichens are an extremely diverse floral group, occupying ecological niches on varied physical and biological substrates such as soil, rocks, and the branches and boles of vascular plants. They lack an epidermis, stomata and a waxy cutin, and consequently lack the control over gas exchange as vascular plants do.

Lichens are sensitive to high concentrations of gaseous pollutants such as sulfur dioxide, and they are accumulators of elements such as trace metals and sulfur.



For this reason, they have been studied and used as indicators of urban pollution and point-source emissions from uncontrolled combustion sources.

Because they can convert atmospheric nitrogen to a form usable by other terrestrial and aquatic plants, lichens are considered to be important contributors to nutrient cycling in some types of ecosystems. For these reasons, a number of federal land management agencies, such as the Forest Service, have had an ongoing interest in studying lichens to determine the presence and effects of air pollutants on natural ecosystems.

Professionals gather

In 1991, the USDA Forest Service and the National Park Service co-sponsored a 3-day workshop of lichen specialists to: 1) review what is known about the suitability of lichens as bioindicators of air quality; 2) recommend research and monitoring procedures to study lichens; and 3) assess the usefulness of data on lichen responses to air pollution.

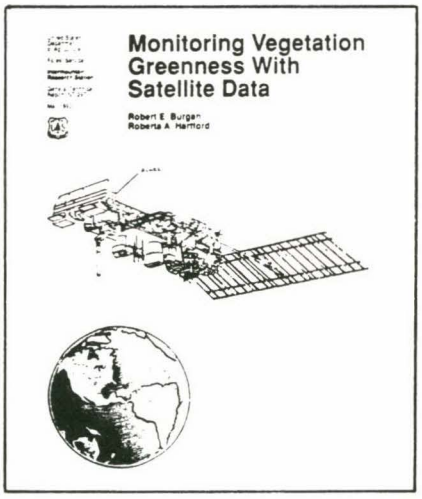
Proceedings of this workshop have now been published by the Rocky Mountain Station. The publication, titled *Lichens as Bioindicators of Air Quality*, General Technical Report RM-224, covers such topics as lichen floristics, identification of lichens that are sensitive to pollutants, characterizing the status of lichen communities, the ability of lichens to accumulate air pollutants, and the usefulness of lichens as biological indicators.

The final chapter provides a conceptual model for integrating the information provided in earlier chapters of the publication. The model is designed to help analyze seven possible air resource management scenarios. Each is illustrated with a case example of an actual air pollution study using lichens. The publication is available from the Rocky Mountain Station.

New from research

Managers can link to satellite that monitors vegetation greenness

Natural resource managers can access satellite data that provides information about vegetation greenness. Interpretation of this data will help managers make proper decisions on things ranging from fire danger to proper timing for tree planting. The hardware needed is a common PC-type computer and modem. The software is comparatively inexpensive.



Researchers Bob Burgan and Roberta Hartford of the Intermountain Station's Fire Behavior unit studied remote sensing technology for assessing the condition of living vegetation that could easily be applied to resource management. Ultimately, the technology will be incorporated into an integrated fire danger/behavior system.
But realizing the immediate value that the technology could have to resource managers, Burgan and Hartford produced this report to help managers know how to use the technology immediately for a variety of other applications.

Included in the report is a complete description of hardware and software needs plus suggestions on how the data can be interpreted and applied to resource management. With the information in this report, space-age technology can be put to work at any location with a PC and a telephone.

Request *Monitoring Vegetation Greeness With Satellite Data*, General Technical Report INT-297, from the Intermountain Research Station.

Proceedings of the Session on Tropical Forestry for People of the Pacific, XVII Pacific Science Conference

This report contains the proceedings of a conference held to describe the roles of the USDA Forest Service's tropical forestry research. Tropical forestry for People of the Pacific is a major undertaking, and for more than 70 years the USDA Forest Service has had an active interest in tropical forestry. Papers included in this proceedings address major questions and issues pertaining to research and management issues, silviculture of tropical and subtropical forest resources, and the relationship of different cultures to forest management.

Request Proceedings *of the Session on Tropical Forestry for People of the Pacific, XVII Pacific Science Conference*, General Technical Report PSW-129 from the Pacific Southwest Research Station.

Proceedings on Western Forest Nursery symposium

The papers presented at last year's Western Forest Nursery Association symposium at Fallen Leaf Lake, California, are now available in a bound publication. The proceedings is a compilation of 25 articles on various aspects of nursery management in western North America. In addition to general nursery technical reports, papers also relate to two special topics: Propagating Native and Adapted Plants for Ecosystem Management and Biodiversity Projects, and Biocontrol Options in Forest and Conservation Nurseries.

The Propagating Native and Adopted Plants for Ecosystem Management and Biodiversity Projects focused on: Types of Plantings, such as "Revegetating Desert Plant Communities", Cultural Methods like "Genetic Considerations in Propagating Diverse Tree Species", and Policy and Marketing papers including "Expanding Your Product Line with Diverse Species". The Biocontrol papers dealt with subjects like "Controlling Root Pathogens with Mycorrhizal Fungi and Beneficial Bacteria".

The proceedings also contains a list of private native plant nurseries and directories for sources of native plant seed. Minutes from the Western Forest Nursery Association business meeting are included as well.

To receive a copy of this publication, request *Proceedings, Western Forest Nursery Association*, General Technical Report RM-221, from the Rocky Mountain Station.

Measuring soil and tree temperatures during prescribed fires

Prescribed burning has been used for many years to achieve a variety of wildland management objectives. To ascertain the effects of prescribed fires on trees, a thermocouple based system was devised for measuring soil cambium temperature. This system is used for data collection, retrieval, and translation.

With enough information on temperature range and duration, it should be feasible to predict fire effects on trees and soil from the amount of fuel consumed. For a copy of *Measuring Soil and Tree Temperatures During Prescribed Fires With Thermocouple Probes*, please request General Technical Report PSW-131 from the Pacific Southwest Research Station.

Forest structure and landscape patterns in the Northern Rockies

To help National Forest managers better assess the effects of fire suppression and logging on landscape patterns and wildlife habitats, researchers Steve Arno, Elizabeth Reinhardt, and Joe Scott developed a method for documenting forest structure and landscape patterns. The method was developed for, and tested in, the lodgepole pine/subalpine fir zone in the Lick Creek Ecosystem Management Demonstration Area in the Bitterroot National Forest in Montana.

Natural ecosystem process disturbances, such as fire and mountain pine beetle epidemics, have recurred for thousands of years, shaping landscape patterns and stand structure. Some patterns can be identified on aerial photographs but the influences of moderate-intensity fires are often not detected using only photographs. In addition, the quantified data produced with the method described in this publication may indicate undesirable conditions or trends and help managers develop better management strategies.

Of particular value, these procedures can help managers detect changes in fire frequency and severity. Date collected can alert them to a trend toward stand-replacing fires.

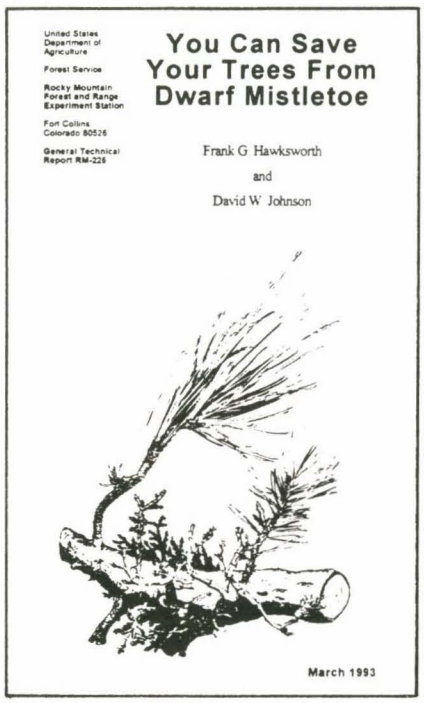
Request *Forest Structure and Landscape Patterns in the Subalpine Lodgepole Pine Type: A Procedure for Quantifying Past and Present Conditions*, General Technical Report INT-294, from the Intermountain Research Station.

The effect of grazing by sheep in a conifer plantation

A major concern today is the effect of treatments on the ecology of a given area. Some of the questions being asked are, how does grazing affect plants that develop in young conifer plantations; and what roles do plant species play in an ecosystem other than being wood or a wood product?

This paper documents grazing over a ten year period and shows the effects of it and other treatments on various components of the plant community. For a copy, please request *Vegetative Trends in a Young Conifer Plantation After 10 Years of Grazing by Sheep,* Research Paper PSW-215 from the Pacific Southwest Research Station.

Fighting dwarf mistletoe



A recently published report on dwarf mistletoe offers a number of control measures for combating this parasitic pest. The manual tells how to identify whether a tree is infected by dwarf mistletoe, how an infection typically occurs, and what procedures can be followed to eradicate mistletoe, while saving the tree. Additionally, the report contains helpful information on preventing further spread of the parasite.

The technical report was authored by the late Dr. Frank G. Hawksworth and Dr. David W. Johnson. Hawksworth, considered a world's authority on dwarf mistletoe, died on January 8, 1993.

For more information, request *You Can Save Your Trees From Dwarf Mistletoe*, General Technical Report RM-225, from the Rocky Mountain Station.

A management strategy to restore forest health at lower elevations in the Blue Mountains

The fire-adapted forests of the Blue Mountains are suffering from a forest health problem of catastrophic proportions.

Contributing to the decline of forest health are such factors as the extensive harvesting of overstory during the 1900s, attempted exclusion of fire from a fire-dependent ecosystem, and the continuing drought.

This publication is part of a series on forest health in the Blue Mountains. The goal of this series is to provide a discussion of forest health issues from various science perspectives.

The series will include discussions on several aspects: insects and disease; economic and social issues; fire; fish, riparian areas, and water quality; ecology and range; wildlife; and a summary of forest health public forums held throughout the Blue Mountains.

Request *Forest Health in the Blue Mountains: A Management Strategy for Fire-Adapted Ecosystems*, General Technical Report PNW-310, available from the Pacific Northwest Research Station.

Lumber and plywood production and prices

Current information on lumber and plywood production and prices; employment in the forest industries; international trade in logs, lumber and plywood; volume and average prices of stumpage sold by public agencies; and other related items is provided.

Request *Production, Prices, Employment, and Trade in Northwest Forest Industries, third quarter 1992*, Resource Bulletin PNW-195, available from the Pacific Northwest Research Station.

Biology, ecology, and social aspects of wild edible mushrooms

The commercial harvest of edible forest fungi has mushroomed into a multimillion dollar industry with several thousand tons harvested annually.

The development of this special forest product industry has raised considerable controversy about how this resource should be managed, especially on public lands.

Concerns center around destruction of forest habitat by repeated entry and harvest, gradual loss of the mushroom resource by potential overharvests, conflict between recreational users and commercial harvesters, and regulation and monitoring of future harvests.

The primary objectives of this overview paper are to provide information on the biology of forest fungi, describe the major edible fungi harvested in the Pacific Northwest, integrate a perspective on the social aspects of the mushroom harvest issue, summarize the development of the commercial mushroom industry, and suggest research and monitoring protocols for developing management guidelines.

Request *Biology, Ecology, and Social Aspects of Wild Edible Mushrooms in the Forests of the Pacific Northwest: A Preface to Managing Commercial Harvest,* General Technical Report PNW-309, available from the Pacific Northwest Research Station.

Conservation of forests of India

This essay discusses current management status of forests and forest wildlife of India in an informal style highlighting the author's travel experiences in the country.

Much of India's forest land has been converted to other uses and remaining forest occurs in small, isolated parks and reserves.

The new national Forest Policy calls for conservation and for meeting people's immense needs for a wide array of forest products.

An ongoing project between the Wildlife Institute of India, and Government of India, and the USDA Forest Service is developing and demonstrating a biodiversity approach to forest conservation in the Satpura Hills of central India.

Request *Conservation of Forests of India: An Ecologist's Tour,* Station Miscellaneous, available from the Pacific Northwest Research Station.

Opinions people have about viewing different types of landscapes

Natural resource managers have long managed landscapes under the watchful eye of the public. Traditional methods for extracting natural resources are increasingly met with vocal objection and legal obstruction. Managers need to know when and where landscape alterations attract public attention and may become visually objectionable.

This research paper reports on a study that investigates the opinions that people had about a series of selected landscapes. The study uses color slides to simulate views of managed and natural landscapes.

Information reported in this study should allow managers to predict when planned actions would lead to public objections, allowing land managers time to develop alternative actions or prepare acceptable explanations of their actions. For a copy of *Assessing Public Concerns for Landscape Quality: A Potential Model to Identify Visual Thresholds*, please ask for Research Paper PSW-203 from the Pacific Southwest Research Station.

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4) *Forest Structure and Landscape Patterns in the Subalpine Lodgepole Pine Type: A Procedure for Quantifying Past and Present Conditions*, General Technical Report INT-294.
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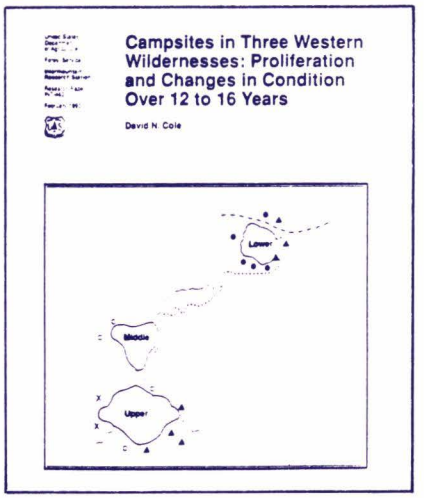
Wilderness campsite proliferation and changes

Scientist David Cole discovered that campsite impacts in wilderness increased during a period of time when there was evidence that wilderness use had decreased. The study showed that the increased impact was a result of campsite proliferation due to a change in the behavior of wilderness users that made them more likely to pioneer new sites rather than camp at existing sites.

In some cases the increased campsite impacts, considered by most wilderness managers to be the greatest wilderness impact, were caused by educational programs designed to disperse users and reduce concentrations at popular areas. Cole observed that the greatest proliferation of campsites was at moderately popular destinations rather than the most popular destinations.

The research led Cole to make management recommendations that differ greatly between the most popular and less popular sites. At heavily used sites Cole recommends that site pioneering be eliminated and campers encouraged to use already impacted sites.

At moderate and lightly used locations a different strategy will be most effective at reducing impacts. At these locations site-pioneering behavior should be encouraged, but only as long as the behavior also includes low-impact practices. Most of the new campsites at these locations are lightly impacted and have the potential to be rehabilitated effectively.


Campsites in Three Western Wildernesses: Proliferation and Changes in Condition Over 12 to 16 Years
David N. Cole
Lower
Middle
Upper

Cole concludes that the results of his research demonstrate the consequences of failure to actively manage campsites. They also demonstrate the importance of basing campsite management on a knowledge of the type and pattern of use.

Request *Campsites in Three Western Wildernesses: Proliferation and Changes in Condition Over 12 to 16 Years,* Research Paper INT-463, from the Intermountain Research Station.

Probability of fire-stopping precipitation

Scientists discovered that they could tell managers, on the day a fire starts, what the odds are that rain will stop the fire's spread by a given date.

From this research they produced probability tables that can help managers decide whether or not to declare a wilderness ignition a wildfire. The tables can help a manager determine on a given date the likelihood of whether it would be less expensive to suppress a fire, or wait for nature to douse it with rain or snow and risk potentially greater costs if nature fails to do the job.

Research Meteorologist Don Latham and Physical Scientist Dick Rothermel of the Intermountain Station's Missoula-based Intermountain Fire Sciences Laboratory analyzed past weather data to learn the probability that precipitation would stop the spread of a fire by a given date. Using the Weibull probability technique, they tested data from four weather stations and found that the method worked well.

To learn more about this research, request *Probability of Fire-Stopping Precipitation Events,* Research Note INT-410, from the Intermountain Research Station.

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